An Analysis of Technical Efficiency and Efficiency Factors for Austrian and Swiss Non-Profit Theatres

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1. Introduction

Measuring the production efficiency of the performing arts and identifying the sources of possible inefficiencies is complicated by the number of factors which are associated with the specific technology underlying production in this sector. At the same time such investigation is particularly important due to the fact that most of performing arts firms are non-profit and they receive substantial amounts of funding from the state, private donors, or are run by governments. Austrian and Swiss theatres examined in this study, like other non-profit performing arts organisations, must also rely on public subsidies and hence they provide an interesting field of research.

Public funding for non-profit theatres is justified as they fulfill socially desirable but not necessarily profitable objectives, such as ensuring high quantity and quality of artistic output at affordable prices. In addition to the benefits gained by individuals who pay to attend a performance, the performing arts generate non-private benefits to the rest of society (O'Hagan, 1998).[1] However, supplying "high-culture" performing arts (symphony concerts, opera, ballet and drama performances) may be very costly for both the theatres and the providers of subsidies.

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1 Performing arts may contribute, for example, to the spiritual well-being of everybody in the country through promoting national identity, social cohesion and national prestige. O'Hagan (1998) provides a detailed overview of such non-private benefits and a brief history of performing arts institutions in Europe.

Baumol and Bowen (1965) were the first to explore the economic problems faced by the producers of the performing arts and they argued that there were few possibilities for productivity improvements in this sector.[2] As Marco-Serrano (2006) points out the live performing arts combine the features of non-repeatability and a high degree of complexity in production. For example, in the short run, the output per man-hour of an actor is fixed and the marginal productivity of a single orchestral performance cannot rise by playing the piece faster or with fewer instruments. Although in the long run all factors of production can be altered, these can be changed only to some extent as output expansion is constrained by the number of performances staged and by the capacity of venues. This particular kind of production technology involves high fixed costs as the organisation, directing, rehearsing, scenery and costume costs are independent of audience size and hence the average total costs will also be higher (Luksetich and Lange, 1995).[3] Given that the productivity remains unchanged, most performing arts firms have to rely on other sources of income, since their production costs will inevitably increase over time relative to their revenues. In fact, many governments and private donors have to meet the rising costs of theatres through further increases in subsidies.

The purpose of the present study is to derive reliable measures of both production efficiency and production technology for the non-profit performing arts organisations in order to reveal possibilities for improving their productivity in the future. In particular, it will be shown that the efficiency of performing arts firms can be measured and compared with regard to the fulfilment of non-financial goals of theatre such as the production of an artistic output. Thus, the measures presented in this paper could serve as useful policy indicators that would enable both the managers of theatres and their patrons to set appropriate levels of public funding and to reduce indirectly the costs of running the theatre. This is especially important as the level of subsidy is supposed to correspond to both the social significance and the artistic level, and therefore is frequently in dispute (Gruber and Köppl, 1998).

2 In line with Marco-Serrano (2006) we interpret productivity as the quantity of output obtained per unit of employed input. Productivity is determined by production technology, environmental factors (heterogeneity of theatres), and the efficiency of the above process, which is estimated in this study.

3 In contrast, the for-profit performing arts firms (e.g. Brodway theatre) produce an output of a lower quality and specialize in one particular play over the entire season. As the result, they have an advantage of spreading their fixed costs over many performances of the particular production.

A novel panel data set on 20 theatres in Austria (over a period of 36 years) and 30 theatres in Switzerland (over a period of 26 years) enables exploration of these issues in detail. The performance of non-profit theatres in Austria and Switzerland is evaluated by estimating their production technology (i.e. output elasticities and returns to scale) and productive efficiency. The latter is defined as *technical efficiency* which is understood as managerial ability at getting the maximal output from available resources with the existing production technology (i.e. the given level of inputs).

In this article, given the available data, two alternative observable output measures are applied which are theatre attendance and the number of tickets on offer. The production technology and the technical efficiency scores are estimated using the stochastic production frontier approach originally developed by Aigner, Lovell and Schmidt (1977). Two extensions of the model are applied in line with Battese and Coelli (1992) and Greene (2005) in order to test whether or not the underlying assumptions of the different methods will have a great impact on the estimated technical-efficiency levels of theatres. In particular, the models which do not take into account both the time-varying inefficiency and the specific heterogeneity of theatres will underestimate the efficiency and will also bias the production function coefficients. This study reveals that recent econometric techniques are able to overcome data measurement constraints and allow for estimation of the efficiency of theatres in a more reliable and concise way.

The paper provides also some insights into the impact of some observable managerial factors on technical efficiency scores such as the competition level (measured by the number of other theatres in the local area) and the level of public subsidies. Some regional differences between theatres are also taken into account which are directly incorporated in the production function. It will be shown that these factors are important and that they reflect the observed heterogeneity of theatres in the countries examined.

The rest of the paper is structured as follows. Section 2 introduces the data sources and the basic characteristics of the non-profit theatre sector in Austria and Switzerland. Section 3 presents the conceptual framework and reviews briefly the previous literature which is related to measuring production technology and productivity in the performing arts sector. Section 4 discusses the dependent and independent variables used in the model and the estimation strategy is explained in Section 5. In Section 6, the empirical results are presented and conclusions follow in Section 7.

2. The Austrian and Swiss Non-Profit Theatre Sector

There are approximately 15 large subsidised theatres in Austria and about 25 subsidised theatres in Switzerland. The major statistical source for these theatres is the yearly *Theaterstatistik* (theatre statistics report). The theatre report has been prepared primarily for German public theatres and orchestras by *Deutscher Bühnenverein* (German Stage Association) since 1965 but it is also a secondary data source for Austrian and Swiss theatres.[4] The data available in *Theaterstatistik* on Austrian and Swiss theatres are directly comparable both between the countries and over time.[5] Figure 1 presents the number of theatres which are included in the yearly issues of *Theaterstatistik* and are examined in this study. The total number of Austrian theatres in the sample is 20 of which 12 are located in Vienna. The total number of Swiss theatres is 30, of which 17 are located in German-speaking and 13 in French-speaking Switzerland. Among theatres located in German-speaking Switzerland, there are also five *Gastspielhäuser* which specialize in producing plays by foreign ensembles and touring companies.[6]

With regard to financing and directing the non-profit theatres, theatres in Austria include four large federal theatres in Vienna (*Bundestheater*), public city and regional theatres in other regions of Austria, also large private theatres in Vienna and smaller private theatres termed *Mittelbühnen*. For the federal theatres in Vienna and other state-run theatres, the government (state, regions and municipalities) has assumed legal responsibility. In contrast, private theatres operate under civil law but the budgetary support is also made available for the large private theatres under a highly differentiated system.[7] Included in the Swiss theatres are the so-called 'established' or 'producing' theatres. In contrast to the theatres in Austria where legal state ownership is predominant, Switzerland has no

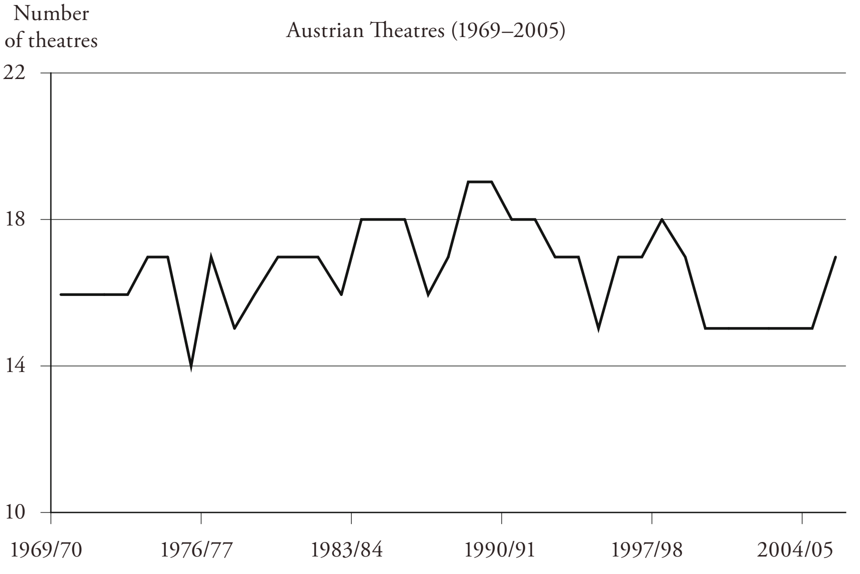
4 *Theaterstatistik* has been provided with the data on Austrian theatres since 1969 by the Austrian Theatre Association, the Vienna Theatre Association, the Theatre Association of Austrian Regions and Towns and with the data on Swiss theatres since 1979 by the Swiss Stage Association. Data on Austrian and Swiss theatres are included in Appendix 1 and Appendix 2 of *Theaterstatistik*, respectively.

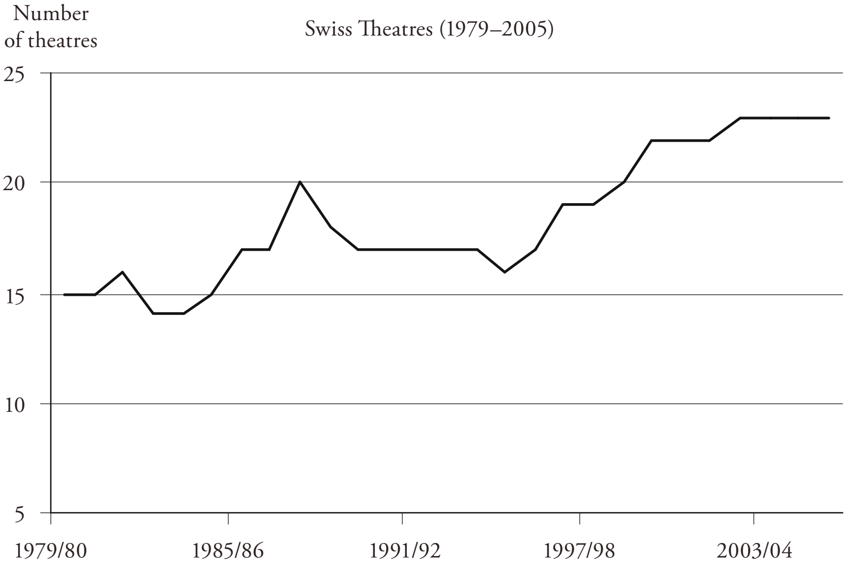
5 The layout of *Theaterstatistik* has not changed substantially since 1965 which enables comparison of data over time. Furthermore, the statistical tables for Austrian theatres correspond in general with those for Swiss theatres, regarding their composition and content.

6 In Austria there are many other small non-profit performing arts institutions subsidized by municipalities which are not included in *Theaterstatistik*. Furthermore, both in Austria and Switzerland there are also small independent companies (*Freie Gruppen*) which operate with no guarantee of receiving public subsidies.

7 The public bodies provide support on a voluntary basis for these theatres but at the same time under the obligations arising from customary practice (GRUBER and KÖPPL, 1998).

Figure 1: Number of Austrian and Swiss Non-Profit Theatres in the Sample





Source: Theaterstatistik, Deutscher Bühnenverein

state or council theatres. The theatres are publicly financed but not run as state cultural institutions governed by laws applying to public institutions (Kotte, 1998). Furthermore, the financing through private donations and sponsorship are not relevant for both Austrian and Swiss theatres (see Gruber and Köppl, 1998; Sivers, Wagner and Wiesand, 2004).

Although all subsidised theatres obtain their 'own revenues' on the market through tickets sales, they can only meet a fraction of the production and running costs even if they are constantly booked out. Based on the data available in *Theaterstatistik*, the level of public subsidies accounted on average for 64 per cent of the total budget for both Austrian and Swiss theatres over the periods of time examined.[8] However, whereas the average budget deficit for Swiss theatres remained in 2004 nearly at the level of 1979, it increased on average for Austrian theatres from 50 per cent in 1969 to 71 per cent in 2004. Figure 2 also presents the real average amount of public subsidies per theatre. While it increased for Austria from €5.7m in 1969 to €16.3m in 2004, it increased for Swiss theatres only slightly from 10.9 million Swiss francs in 1979 to 11.2 million in 2004.

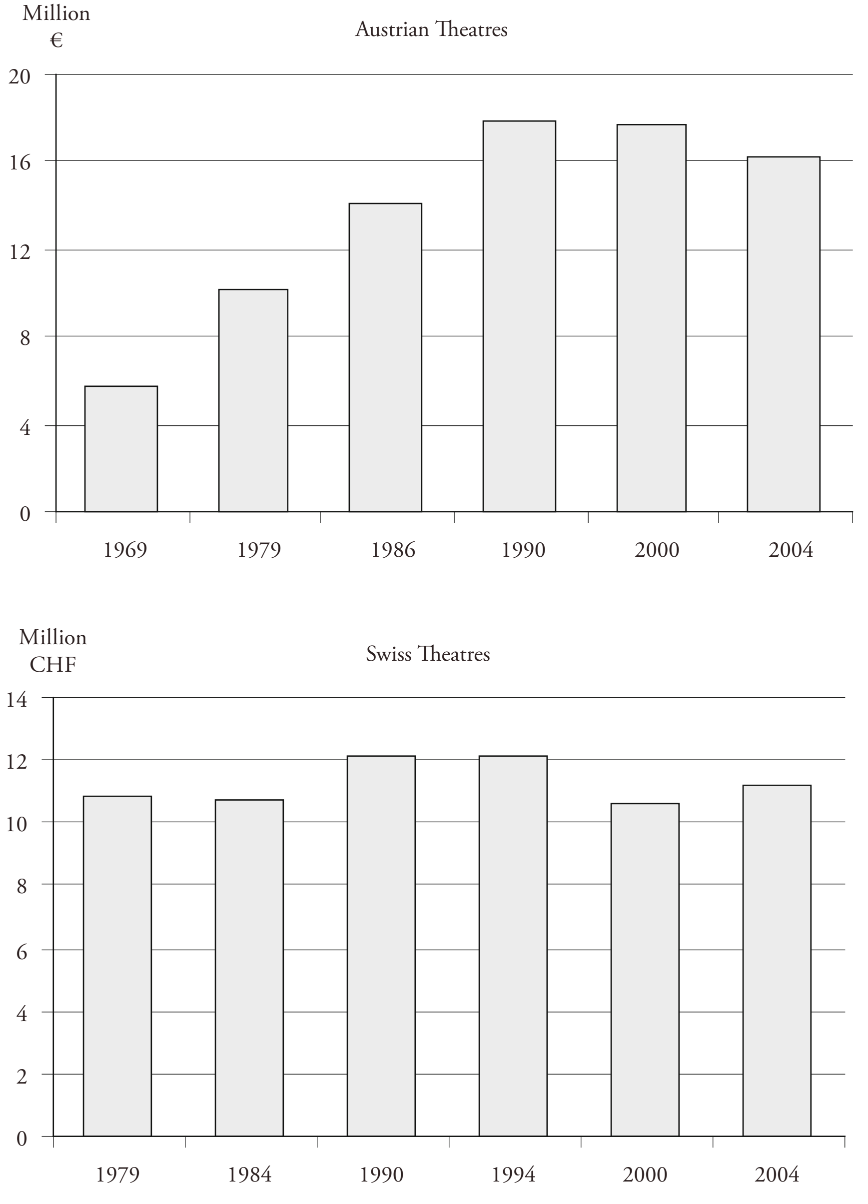
With regard to production structure, all non-profit theatres in Austria and Switzerland can be described as three-branch theatres or multi-branch theatres meaning that many have drama, music theatre (opera/operetta/musical) and ballet/dance productions in their repertoire.[9] This implies that a variety of performing arts forms are generally offered by single theatre enterprises. The theatres are also described as repertory theatres, which means that each production is performed (re-run) several times during the theatre season and several productions are run simultaneously. In large theatres up to 20–25 new productions are performed in a season, with few evenings where the same performance is shown. The theatre season usually lasts 12 months with 10 or 9 months of playing and 2 or 3 months of preparation for the new theatre season. The production program is prepared and published at the beginning of each season.

All Austrian theatres and all 'established' theatres in German-speaking Switzerland have a permanently employed artistic ensemble consisting of solo artists, choir, ballet and theatre orchestra members. The employment rights of artists are regulated by the Austrian and Swiss Stage Associations. However, the established theatres in the French-speaking part of Switzerland (with the exception of *Grand*

8 The total theatre budget consists of public subsidies and own revenues from the tickets sales.

9 In addition, some Austrian and Swiss theatres have integrated theatrical orchestras. The orchestras' main task is playing in music theatre but they are also staging additional concerts.

Figure 2: Average Amount of Public Subsidies per Theatre



Source: Theaterstatistik, Deutscher Bühnenverein

Théâtre de Genève) and *Gastspielhäuser* in German-speaking Switzerland do not employ an artistic ensemble on a full-time basis. These theatres promote guest performances and co-productions based more on the en-suite principle (KOTTE, 1998). Thus, they usually employ foreign ensembles for much shorter periods of time and these artists are remunerated on a per-production basis.[10] Nonetheless, all Austrian and Swiss theatres employ an artistic director who decides the artistic production program, repertoire and ensemble in association with other artistic management such as dramaturges or stage managers.[11] Support staff consisting of technicians, artistic-technical staff (for example stage designers), administrative and house staff are also employed on a full-time (permanent or temporary contracts) or part-time basis. All theatres also have their own venues which often consist of one large and several small auditoriums granted to them by the state, municipalities, regions in Austria or cantons in Switzerland.

3. Related Literature and Conceptual Framework

There are several empirical studies which are related to measuring production technology and also efficiency of the performing arts sector from both the production and cost-function perspectives.[12] While BAUMOL and BOWEN (1965) recognised the economic problems faced by the producers of the live performing arts, THROSBY (1977) was the pioneering work in estimating the production technology of this sector. He used theatre attendance as a measure of artistic output and estimated both the short-run and long-run Cobb-Douglas production functions for non-profit performing arts organisations in Australia.

GAPINSKI (1980; 1984) defined artistic output in terms of "cultural experiences" and also used as a measure of artistic output the number of paid attendances of the non-profit performing arts firms in both the US and the UK. He also applied a more flexible, transcendental production function[13] and distinguished between primary inputs such as artists or capital and secondary inputs

10 Since the data on the number of artists is not available for these theatres in *Theaterstatistik*, this will have implications for the model specification in Section 4.

11 In state-owned theatres, the management is usually appointed by the responsible license holder (i.e. state, region or municipality). In the case of theatres with private ownership external governmental institutions are entitled to control them.

12 In line with the duality theory, cost functions can also be used to study the underlying production structure under certain conditions provided that the data on input prices and output levels are available.

13 This functional form is a non-homogenous 'cousin' of the Cobb-Douglas function.

such as ancillary staff. His findings indicate that performing arts firms produce in the economic region with positive and diminishing marginal product for the primary inputs, and with positive but increasing marginal product for the secondary inputs. Furthermore, he found that decreasing returns to scale apply over the whole range of inputs. These findings validated the Baumol and Bowen's hypothesis that the performing arts belong to the stable productivity sector.

Recently, Zieba and Newman (2007) revisited issues addressed by Gapinski (1980) and confirmed his earlier findings by estimating the transcendental production function for German public theatres. They defined theatre attendance as artistic output and estimated an "average" production function for panel data using the fixed-effects estimation method. Last and Wetzel (2010), using the same data source, examined input-oriented efficiency for the public theatres in Germany and estimated both the translog input distance and cost functions. As an output they defined the number of seats on offer and incorporated recently developed stochastic frontier techniques in line with Greene (2005). Some of these frontier methods are also applied in this study as they allow us to estimate the efficiency of theatres and to control for their unobserved heterogeneity.[14]

Another approach was undertaken by Marco-Serrano (2006) who applied the data envelopment analysis (DEA) as a non-parametric method of measuring the technical efficiency of non-profit theatres in one region of Spain. Marco-Serrano measured output-oriented technical efficiency as the ability of cultural managers to convert the available inputs into cultural outputs. He also used two output measures such as the number of performances and theatre attendance but he did not impose any functional form of production function. Hence, the DEA approach is not applied in this study as it does not allow for random shocks in the production process which are then not separated from the inefficiency term.[15]

Many other empirical studies have relied on estimation of cost functions for the performing arts sector and their main emphasis has been on finding evidence for scale economies. Globerman and Book (1974) estimated cost functions for symphony orchestras and theatre groups using the number of performances as

14 Both studies on German theatres used the panel data from *Theaterstatistik* which is also the data source for Austrian and Swiss theatres (see Section 2). The results obtained in this study will be compared with the findings of Zieba and Newman (2007) with regard to production technology and with the findings of Last and Wetzel (2010) with regard to econometric methods.

15 Another study that applied DEA analysis was also conducted by Tobias (2003) who similarly to Last and Wetzel (2010) analysed cost efficiency for German theatres using similar data.

artistic output. THROSBY (1977) also estimated a Cobb-Douglas cost function. TAALAS (1997) explored in greater detail the structure of production of Finnish theatre and applied a flexible translog cost function. Her results confirmed the existence of economies of scale but she also investigated the assumptions of the homotheticity and homogeneity of the underlying production technology. Additionally, FAZIOLI and FILIPPINI (1997) examined the cost structure of local public theatre in Italy using a flexible translog cost function and also confirmed the evidence of economies of scale.[16]

The estimation of the cost function is not pursued in this study due to the fact that the assumption of cost minimization may be unrealistic for Austrian and Swiss non-profit theatres which must rely on public funding (see also LAST and WETZEL, 2010). On the other hand, PESTIAU and TULKENS (2006) point out that the output relationships of non-profit firms may be amenable to analysis with the familiar techniques of neoclassical production theory. Thus, in line with THROSBY (1977) and MARCO-SERRANO (2006) we describe the performing arts firms as constrained output maximizers with quality of services playing a significant role. Following FARRELL (1957) and assuming that inputs (X_k) are exogenous, we measure an output-oriented technical efficiency (TE_{it}) which is the ratio of the observed output (Y_{ikt}) of theatre i in period t, relative to the maximal potential artistic output, defined by the frontier function $Y_k = f(X_1, \ldots X_K)$. The technical efficiency is bound by zero and one and a score of less than one means that the theatre is inefficient as it could potentially increase its output level without increasing its inputs. Both the production technology and the technical efficiency scores are estimated using three alternative stochastic frontier methods which are discussed in Section 5. The results are compared across different specifications in order to examine the importance of unobserved heterogeneity of theatres. Additionally, we examine the effects of some observable theatre-specific factors which may also directly affect both the estimated production technology and the technical efficiency scores.

16 Whereas TAALAS (1997) used theatre attendance as a measure of output, FAZIOLI and FILIPPINI (1997) used the number of performances and they included other variables in the cost function in order to capture differences in quality.

4. Model Specification and Data Set

The subject of this section is the description of the dependent and independent variables used to estimate the stochastic production frontier for both Austrian and Swiss theatres. Firstly, we define two measures of artistic output (Y_k) which will identify two alternative production function models and we also discuss the choice of variables used as inputs (X_k).[17] Secondly, we define the variables (Z_k) which are neither inputs nor outputs of the production process but they are assumed to affect directly either the production level or the technical efficiency scores of theatres.

To construct all variables, unbalanced panel data are collected for 20 Austrian theatres over the period 1969/1970–2004/2005 and for 30 Swiss theatres that operated between 1979/1980 and 2004/2005. This gives the total number of 536 observations for Austria and 526 observations for Switzerland. All variables correspond to each theatre i and yearly theatre season t. Most of the variables are constructed using *Theaterstatistik* as the main data source. The description of all data sources and variables used are provided in the Appendix.

4.1 Artistic output (Y_k)

Two alternative definitions of artistic output are considered: the number of visitors, Y_1 and the number of tickets on offer, Y_2. Theatre attendance, Y_1, is calculated as the total number of paying theatre visitors. It includes aggregated tickets sales at own location of theatre i in season t and it consists of visitors attending drama performances, musical theatre (opera, operetta, musicals) and also ballet and classical concerts. Theatre attendance also includes visitors attending performances staged by foreign ensembles but it does not include attendance at guest performances.[18] Theatre attendance is regarded in this study as the most appropriate output measure. According to Gapinski (1980; 1984), Throsby (1977), Taalas (1997) and Marco-Serrano (2006) artistic output should be defined in terms of "cultural experiences" as the contact with an audience is an essential ingredient of it. This output variable has another advantage in that it also incorporates the objective dimension of quality which is evaluated by theatre

17 The output distance function approach is not applied in this study as it is assumed that the technical efficiency levels and efficiency factors will change with regard to different interpretations of artistic output.

18 In fact, not many theatres go on tour - on average only 5 per cent of performances are staged as guest performances in Austria and about 12 per cent of all performances produced by Swiss theatres are guest performances.

visitors.[19] According to this interpretation artistic output cannot be a single performance or the number of tickets available for a single performance.

The number of visitors may, however, be seen as a function of both supply and demand. We could, for example, assume that a given increase in inputs will have a greater impact on output in a larger market (with no theatre competitors) as there would be more consumers who could see the show. Thus, in order to check for any differences in the results, the second measure of artistic output applied in this study is the number of tickets available on offer, Y_2. This variable is calculated by multiplying the number of all performances (re-runs) staged at own location by the number of all seats available in all venues of theatre i in season t (see also Appendix). According to HEILBRUN and GRAY (1993), the advantage of this output variable is that it shows the real supply of theatre and the problem of interlinking with demand effects can be avoided. However, the number of tickets on offer is not consistent with our previous interpretation of artistic output as a cultural experience and the audience preferences are not taken into account using this output measure.

It should also be noted that both observable output measures which are used in this study do not take into account the full dimension of artistic quality. Even if we interpret artistic output as a "cultural experience", quality will remain different for each individual attending a given performance and it will depend on tastes and the skills of the artistic interpretation (HEILBRUN and GRAY, 1993). Additionally, there are also subjective aspects of quality which are assessed not by the visitors but by the theatre directors themselves. These specific quality factors are not observed but they may be related to unobserved heterogeneity of theatres and will have important implications for the choice of the econometric model presented in Section 5.

4.2 Inputs (X_k)

As with most types of firms, in the performing arts sector we can also broadly classify inputs as labour and capital. In this study, the factor inputs are constructed using the yearly personnel expenses and other expenses data[20], the capacity of theatrical venues and, in the case of Austrian theatres, also the data on personnel numbers.

19 O'HAGAN and ZIEBA (2010) also examine theatre attendance from an objective quality perspective.

20 In contrast to Swiss theatres, the expenses for Austrian theatres are reported for the fiscal year and they are transformed into theatre season equivalents in line with TOBIAS (2003) by weighting the expenses of the current fiscal year by 5/12 and the expenses of the following fiscal year by 7/12.

The labour input is the most important factor of production in theatre and its flow should be considered as much as possible by using the real measure of man-hours. Furthermore, due to the fact that an artistic performance cannot take place without artists, the distinction between artistic and non-artistic labour is particularly important. This, however, is possible only for Austrian theatres for which the data on personnel numbers classified by different categories of employees are available. For these theatres two labour inputs are constructed in line with Gapinski (1980), Zieba and Newman (2007). These are: artists (ART_{it}) which include artistic directors, stage managers and technicians, solo artists (for opera/operetta, drama and guest artists), ballet members, choir and orchestra members; and ancillaries (ANC_{it}) which include administration and house staff. [21] Due to the fact that the time period for estimation of production function for Austrian theatres is 36 years, a considerable variation in the numbers of employees can be expected. As such, the man-hours can be sufficiently approximated using the personnel numbers. Nevertheless, applying this measure, we must strictly assume full-time employment and that all employees work regular hours during the entire theatre season.

The personnel numbers were not used to measure the labour input for Swiss theatres, as the exact data on the number of employees are not available (see also Section 2). For these theatres, the labour input is derived using data on aggregated personnel expenses which are, however, not classified in *Theaterstatistik* by different categories of employees. An aggregated labour input (LAB_{it}) is constructed using total man-hours which are obtained by dividing aggregated personnel expenses of all employees in a theatre by the relevant nominal wage rate in Switzerland (see Appendix). [22] Although the assumption of homogenous wage rates is not very realistic it was not possible to use differentiated salaries for Switzerland which could be classified by the geographical location or by different professions.[23] Nevertheless, in contrast to the personnel numbers, the personnel

21 The guest artists are employed on a part-time basis and their numbers are weighted by 0.5 in order to convert them into the full-time equivalents.

22 The aggregated labour input was also calculated for Austrian theatres. With regard to the production function parameters and the estimated technical efficiency scores, the alternative results did not differ notably from the results presented in Section 6. These results are, however, not presented as the classification between artists and ancillaries is considered as a better specification.

23 To check for any possible biases connected with using the homogenous wage rates for Swiss theatres, we also obtained the results without converting the personnel expenses into man-hours and the results are very similar to those presented in Table 3 of Section 6.

expenses express the actual real labour usage in a theatre as they include overtime payments, payments for part-time employees and guest workers.

In the absence of direct information on capital-inputs flow a proxy capital variable is constructed using data on capital expenses (see also GAPINSKI, 1980). The capital expenses are available in the *Theaterstatistik* and are divided into two main categories: 1) direct expenses for décor and costumes, stage design and equipment and 2) other expenses. The capital input is approximated using only the first expense category as the 'other expenses' may not fully reflect the commodity usage in a theatre. This variable is denoted as DEC_{it} and converted into real values by using the wholesale price index for Austria and the implicit price deflator for Switzerland. Furthermore, a proxy variable for capital stock, $CAPS_{it}$, is constructed in line with FAZIOLI and FILIPPINI (1997) which is taken to be the number of seats in theatre *i* and season *t*. In this study a long run production function is applied and hence we can assume that during this time all inputs of artistic production, including theatre capacity, can be altered.

4.3 Determinants of Technical Efficiency (Z_k)

The efficiency determinants are interpreted in this paper as observed managerial or regional factors which can be taken into account by incorporating them either in the estimated distribution of inefficiency or directly in the production function. According to GREENE (2004) there is no clearly defined rule which indicates how these factors should enter the model. In this study, we firstly assume that the level of public subsidies and the level of competitiveness in the market are the managerial determinants which influence directly the technical efficiency of theatres. Secondly, we believe that the regional differences between theatres have an important influence on the production structure and consequently they will shift the production frontier.

The first efficiency factor, SUB_{it}, is constructed by dividing the real level of public subsidies, received by theatre *i* in season *t*, by the number of all seats in theatre. The overall influence of public subsidy per seat on technical efficiency of theatres is difficult to predict but one could expect the effect of subsidies to be positive. Public funding may be correlated, for example, with higher expenditures on more talented artists or renovation of an auditorium which would in turn increase quality and hence the output of theatre by the given level of inputs. Nonetheless, the subsidies could also be spent on intangible aspects of artistic output that are not measured by visitor numbers or tickets on offer and they could also influence negatively the efficiency of theatres. Finally, the standard argument could apply that public funding might have an adverse effect on the incentives of the theatre management and the employees to be efficient (see also Bishop and Brand, 2003).[24]

The second important efficiency factor is the level of competitiveness in the market for theatre. Following Propper, Burgess and Green (2004), we use a simple measure of competition which is the number of potential competitors, NUM_i, located in the relevant area of theatre i.[25] For Swiss theatres it is the number of theatres in the canton and for Austrian theatres it is the number of theatres in the federal region where theatre i is located. We assume that the number of theatres should have a positive effect on incentives of cultural managers and will increase technical efficiency. This may hold as theatre managers may compete, for example, for higher reputation among their peers where there are more theatres in close proximity. Additionally, where many non-profit theatres fall under the remit of a particular public authority, comparisons in the performance of theatres, both in terms of artistic output and economic goals outcomes, can be made more easily which in turn may also positively affect efficiency.

Furthermore, the regional differences of theatres are assumed to affect the production technology. We account for such differences between German-speaking and French-speaking Swiss theatres by constructing a dummy variable, D_i, which is coded 1 if a theatre i is located in the German-speaking part of Switzerland and 0 otherwise. There is no reason to expect any particular sign for the coefficient of the dummy variable for Swiss theatres. For Austrian theatres, a dummy variable is set to 1 if a theatre is located in Vienna and zero otherwise.[26] According to Gruber and Köppl (1998), Vienna has been at the centre of Austrian theatre life for centuries. Furthermore, more than half of Austrian theatres in the sample are in fact located in the region of Vienna, including the four federal theatres which belong to the largest theatre group in the world and which also

24 Bishop and Brand (2007) applied the number of visitors as a measure of output for museums and also examined the direct impact of private funding on technical efficiency. However, they used a dummy variable taking a value of 1 if private funding was smaller than 90 per cent and 0 otherwise.

25 This measure does not take into account the population to be served by a theatre. The smaller this population for a given number of theatres, the more spare market for theatre and so the larger the potential amount of competition. However, any measure of the relevant population for theatres in Austria and Switzerland will be arbitrary and therefore it is not included in this variable.

26 Initially, the dummy variables were created for each federal region in Austria and each canton in Switzerland. The dummy variables were jointly not significant and hence this approach is not applied.

attract many theatre visitors from abroad. Thus, it is expected that Vienna's theatres will generate higher output by the given level of inputs than the theatres in other regions of Austria.

4.4 Descriptive Statistics

Table 1 provides summary statistics for the key variables used in the analysis. All money values are converted into real values for the year 2000 and are expressed in EUR prices for Austria and in CHF prices for Switzerland. Considerable variation exist in outputs and inputs for both Austrian and Swiss theatres. On average, theatres in Austria produce twice as many theatre visitors and tickets on offer as Swiss theatres. The differences in output are connected with the different amount of inputs used. For example, the number of seats ($CAPS_{it}$) is twice as large in Austria in comparison with Switzerland. This is also consistent with the fact that Austrian theatres use on average twice as many man hours (LAB_{it}) as Swiss theatres.

The capital input (DEC_{it}) and the level of public subsidy per seat (SUB_{it}) are expressed in deflated nominal values and as such they are not directly comparable between the countries. However, approximating the expenses by applying the historic currency exchange rates, it can be found that the theatres in Switzerland have on average only slightly lower expenses on décor and costumes, DEC_{it}, than Austrian theatres whereas the level of subsidies per seat (SUB_{it}) is twice as much for Austrian theatres as for Swiss theatres.

Furthermore, the average number of theatres in the region equals 7.4 in Austria and about 4.3 in Switzerland. In addition, 12 theatres in Austria are located in Vienna while other theatres are scattered over different regions in the country. Thus, the number of theatres which are located in the same region is much smaller in the case of Swiss theatres. This is also consistent with the fact that the standard deviation is much lower for these theatres.

It might be also instructive to provide some broad trends of the dependent variables used to estimate the model. Figure 3 presents the theatre attendance and the number of tickets on offer calculated as an average for the theatres in the sample. While theatre attendance decreased in Switzerland from 111,130 visitors per theatre in 1979/1980 to 64,532 in 2004/2005, it decreased only slightly in Austria and from a higher base, from 259,660 visitors per theatre in 1969/1970 to 240,976 in 2004/2005. A similar pattern can be observed for the artistic output measured as the supply of the tickets available on sale which decreased from 159,234 to 100,248 for Swiss theatres and from 378,043 to 304,927 for Austrian theatres. The same figure shows that the number of visitors is always

Table 1: Summary Statistics

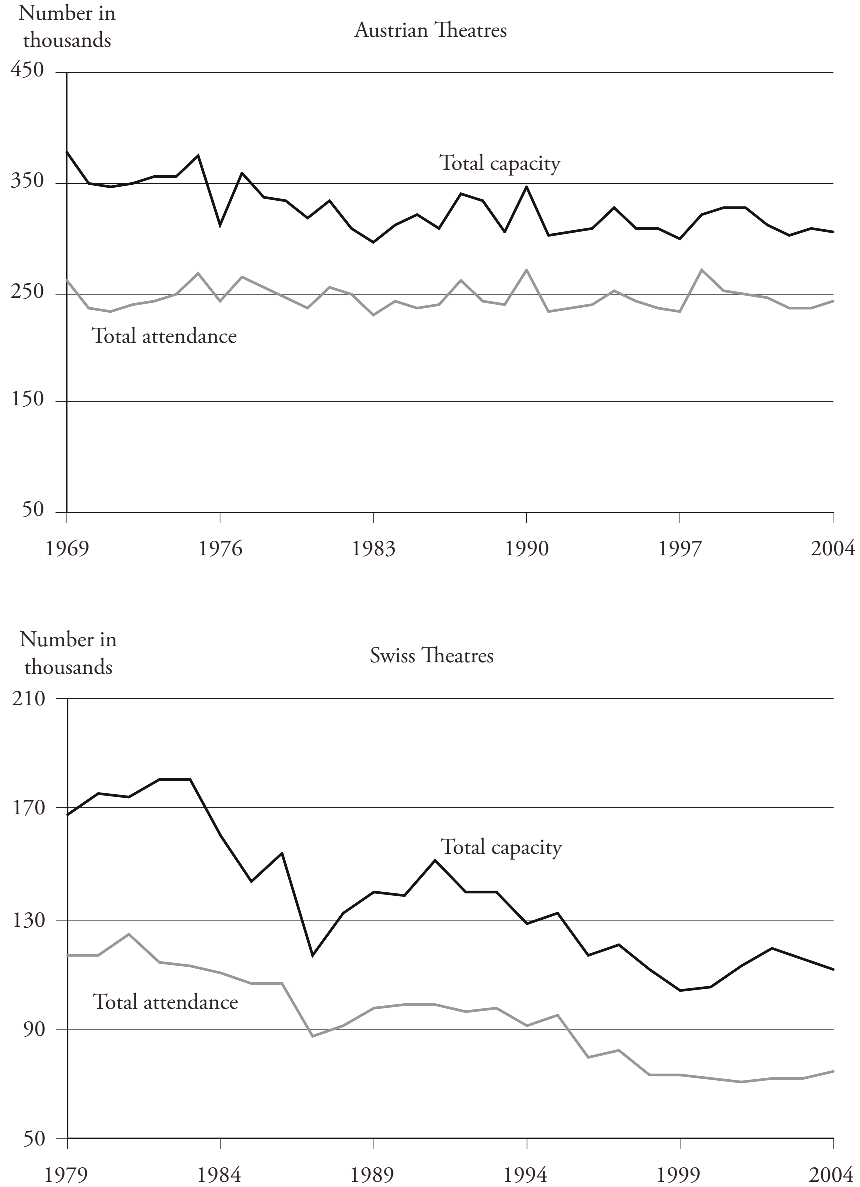
	Austrian Theatres		Swiss Theatres	
	Mean	Std. Deviation	Mean	Std. Deviation
Artistic output (Y_k)				
Theatre attendance (Y_1)	249,286	164,881	82,102	73,935
Tickets on offer (Y_2)	330,503	199,725	120,592	112,111
Inputs (X_k)				
Number of Artists (ART_{it})	352	271	n/a	n/a
Number of Ancillaries (ANC_{it})	52	47	n/a	n/a
Man hours (LAB_{it})	872,793	972,549	322,549	480,514
Décor & costumes (DEC_{it})	777,556	1,196,640	958,357	1,211,811
Capital stock ($CAPS_{it}$)	1,628	930	729	554
Determinants of efficiency (Z_k)				
Subsidy per seat (SUB_{it})	13,835	15,280	11,069	14,734
Number of theatres (NUM_i)	7.4	5.9	4.29	2.12

greater than the number of tickets on offer which indicates that on average the capacity constraints are not an issue for the theatres in question.[27]

It is also noteworthy that a greater decrease in artistic output for Swiss theatres corresponds with a lower increase in the public subsidies per seat which increased only from 11,120 CHF in 1979 to 12,978 CHF in 2004 (see also Figure 2 in Section 2). On the contrary, the increase in public subsidies per seat for Austrian theatres was quite large with 3,652 EUR in 1969 and 9,869 EUR in 2004, while theatre attendance and the number of tickets on offer decreased very little over this time period. This statistics indicates that the public subsidies may have a positive effect on the production of artistic output and hence on the efficiency of theatres.

27 In fact, the capacity utilization (calculated by dividing theatre attendance by the number of tickets on offer) equals 0.75 and 0.71 on average for Austrian and Swiss theatres, respectively. Thus, it is never close to one for any theatre in the sample. Nevertheless, this measure is calculated as an average for the yearly theatre season and the capacity constraints can still apply for a single performance.

Figure 3: Average Number of Visitors (Y_1) and Tickets on Offer (Y_2)



Source: Theaterstatistik, Deutscher Bühnenverein

5. Estimation Strategy

The parametric estimation of the stochastic production frontier requires the specification of the mathematical form of the production function. We consider firstly a flexible translog functional form which allows the output elasticities and returns to scale to vary with the inputs levels and it also places no restrictions on substitution elasticities. However, the translog function requires the estimation of a large number of parameters which provides the potential risk of multicollinearity. Our preliminary analysis revealed that a numerically feasible estimation of this function is only possible for Austrian theatres. For Swiss theatres, the standard Cobb-Douglas function is applied which due to the limited number of variables has a practical advantage in statistical estimations over more complicated forms. For Austrian theatres, the translog production function also requires the second-order approximation of the underlying production function at a local point which in our case is taken as the sample mean. Thus, all variables for these theatres are normalized by their corresponding sample means.

We utilize the parametric stochastic frontier approach which has been proposed by Aigner, Lovell and Schmidt (1977). Expressing output and inputs in natural log values, the translog production function for Austrian theatres can be written as:

$$\ln Y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln X_{ikt} + 0.5 \sum_{k=1}^{K} \sum_{l=1}^{L} \beta_{kl} \ln X_{ikt} \ln X_{ilt} + \beta_t \tau + v_{it} - u_{it} \quad (1)$$

and for Swiss theatres the simple Cobb-Douglas production technology is assumed: [28]

$$\ln Y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln X_{ikt} + \beta_t \tau + v_{it} - u_{it} \quad (2)$$

where Y_{it}, X_{ikt} and X_{ilt} represent the observed output and inputs of theatre i in time period t with $k = 1,\ldots,K$ and $l = 1,\ldots,L$; β_0 , β_k, β_{kl}, β_{lk}, β_t are the parameters to be estimated, τ is a linear time trend which captures the effects of neutral

28 The translog function, given in equation (1), reduces to the standard Cobb-Douglas function for $\beta_{ll} = \beta_{kk} = \beta_{lk} = 0$. For the Cobb-Douglas specification the restriction of a homogenous function is imposed. For Austrian theatres, the Cobb-Douglas specification was tested against the translog function using the log-likelihood ratio tests and it was always rejected at the 1 per cent level of significance.

technological change, v_{it} is the statistical noise term with zero mean and constant variance; u_{it} is a non-negative stochastic term that represents technical inefficiency (i.e. the amount by which a theatre fails to reach the frontier) and has a half-normal distribution so that $u_{it} \sim N^{+}(0,\sigma_u^2)$. Both v_{it} and u_{it} can be expressed as a composite error, that is: $\varepsilon_{it} = v_{it} - u_{it}$. The model is estimated using the maximum likelihood estimator and the inefficiency term is computed using the conditional mean of the inefficiency term in line with JONDROW et al. (1982) so that $E[-u_{it} \mid v_{it} - u_{it}]$. Furthermore, given the logarithmic functional form in equations (1) and (2), the technical efficiency of theatre *i* in theatre season *t* is predicted as:

$$TE_{it} = \exp(-u_{it}) \tag{3}$$

The stochastic frontier model specified in equations (1) and (2) is defined as the *pooled* model due to the fact that it considers each observation as an independent cross-section. This property implies that the inefficiency of theatres is time-varying which according to FARSI and FILIPPINI (2006) is an appropriate assumption given the fact that the inefficiency is a dynamic phenomenon. This holds especially for our analysis as the number of time periods in the panel is large for both Austrian and Swiss theatres, respectively and thus, a persistent inefficiency is extremely unlikely.

In the pooled model, any theatre-specific effects are, however, assumed to be zero. According to FARSI, FILIPPINI and GREENE (2006), the omission of such heterogeneity may lead to biased estimates of parameters describing the production frontier and also to an overstatement of technical inefficiency, u_{it} and hence understatement of technical efficiency, TE_{it}. The inclusion of time-invariant unobserved heterogeneity in the efficiency model for theatres is essential as their output is very heterogeneous due to the importance of artistic quality. LAST and WETZEL (2010) also note that the theatres operate in different regions with various environmental factors and characteristics that are only partially observed.

One of the first proposed modifications of the pooled model is the random effects model of PITT and LEE (1981) which assumes that the inefficiency term is theatre-specific so that u_{it} is constant over time and is replaced in equations (1) and (2) by $u_i \sim N^{+}(0,\sigma_u^2)$.[29] This model is, however, not applied to our data as

29 SCHMIDT and SICKLES (1984) proposed the fixed-effects approach to estimate technical efficiency. However, this approach is flawed in that the inefficiency term is not random and is estimated as an intercept for each theatre. Hence, this model does not provide realistic estimates of inefficiency.

u_i is absorbing any time-invariant heterogeneity of theatres, leading to a downward bias of the estimated technical efficiency scores. In this study we firstly test a time-varying model of Battese and Coelli (1992), defined further as *BC* model, which is an extension of the Pitt and Lee (1981)'s version. This model also takes advantage of panel data and it additionally assumes that the inefficiency is a systematic function of time so that u_{it} is replaced in equations (1) and (2) by $u_{it} = u_i \times \exp[-\eta(t-T)]$ where $u_i \sim N^+(0,\sigma_u^2)$ and η is an unknown scalar parameter to be estimated.[30] Following this, for η>0, the inefficiency term is always decreasing and for η>0 the inefficiency is always increasing with time. If $\eta = 0$, the BC model reduces to the Pitt and Lee's version so that we can test for this form of time evolution of inefficiency.

Under the assumption that the firm-specific effects are uncorrelated with the explanatory variables, the BC model has an advantage over the pooled model in that it provides unbiased estimates of the production function parameters. In this specification the inefficiency is, however, forced to be monotonous function of time and hence the temporal pattern of efficiency is the same for all theatres. Furthermore, Greene (2004) points out that the scale factor, η, brings only a very minor change in the year to year estimates of u_{it} and the underlying component of inefficiency actually remains time-invariant. Thus, for this method we expect a downward bias in the estimates of the technical efficiency scores in the similar way as in the Pitt and Lee (1981)'s specification.

The limitations of the previous time-varying specifications can be overcome with the true-random effects (*TRE*) model recently proposed by Greene (2004; 2005). In line with this specification, the pooled model presented in equations (1) and (2) is extended by adding a theatre-specific stochastic term, α_i, in the right-hand side of both equations, which is an i.i.d. random component. In this specification, ε_{it} is interpreted as the two-part composite error which is not normally distributed and the model is estimated by applying simulated maximum likelihood procedure according to Greene (2005).[31] The TRE model has two important advantages. Firstly, in contrast to the pooled model, it controls for any omitted variable biases due to the unobserved heterogeneity of theatres. Second, in contrast to the BC model, it also avoids heterogeneity biases in the estimates of technical inefficiency. This model has had in fact numerous applications in

30 The model estimates are obtained using the log-likelihood function derived in Battese and Coelli (1992) and the technical efficiency scores are computed as the expected value of the efficiency conditional on the random composite error, i.e. $TE_{it} = E[\exp(-u_{it} | v_{it} - u_{it})]$.

31 The inefficiency term, u_{it}, is obtained by the conditional mean of the inefficiency term so that $E[-u_{it} | \alpha_i + \varepsilon_{it}]$ and the TE_{it} score is obtained in line with equation (3).

recent studies as it allows for both time-varying inefficiency and the firm-specific heterogeneity of theatres.[32]

It should also be noted that the TRE model provides unbiased estimates of the production functions parameters under the assumption of no correlation between firm-specific effects (α_i) and the explanatory variables. However, as Farsi et al. (2005) point out, at least time-variant efficiency measures are not very sensitive to such a correlation because the latter may be captured by the coefficients of the production function and not affect the residuals.[33]

Further purpose of this study was the examination of the efficiency determinants which relate to the observed heterogeneity of theatres and which can be incorporated both in the production function and in the estimates of inefficiency. In the latter case, we are interested in models in which observable exogenous variables directly affect the inefficiency, u_{it}. Following Greene (2007), Hadri, Guermat and Whittaker (2003) we include the efficiency determinants Z_k as heteroscedastic variables in the inefficiency function, directly parameterising the variance of the inefficiency. Formally, this specification is given by equation (4):

$$\sigma^2_{u_{it}} = \exp(\gamma' z_{it}) \tag{4}$$

where z_{it} is a vector of managerial variables discussed in Section 4, including a constant, that influence the inefficiency of theatre i in period t and γ is a vector of unknown coefficients to be estimated. An important advantage of the specification given by equation (4) is that it facilitates the estimation of the inefficiency effects simultaneously, as a one step procedure, with the parameters of the stochastic frontier given by equations (1) and (2).[34] Furthermore, applying

32 This model was applied to examine the cost efficiency for many sectors, such as Swiss nursing homes (Farsi, Filippini and Kuenzle, 2005), the electricity distribution sector in Switzerland (Farsi, Filippini and Greene, 2006) and also German public theatres (Last and Wetzel, 2010).

33 A better alternative to control for the correlation bias would be the TRE model with Mundlak adjustment (see Farsi et al., 2006). The estimation of this model was not possible in this study due to the large number of parameters required for the estimation. Alternatively, the standard fixed-effects (FE) estimator can be used to check for a potential correlation bias in the production function coefficients.

34 Pitt and Lee (1981) used a two-stage method to examine the sources of inefficiency. In the first stage, conventional estimates of inefficiency were obtained and in the second step these estimates were regressed with exogenous factors. This procedure arouses, however, the inconsistency in the assumptions about the distribution of the inefficiency since the estimates of u_{it} will be biased by the omission of Z_k-variables in the first step regression.

this specification within the TRE model framework, we are able to control for both observed and unobserved heterogeneity of theatres. HADRI et al. (2003) combine the approach with the BATTESE and COELLI's (1995) model which includes the inefficiency factors directly in the mean of the inefficiency function where u_{it} is assumed to be independently distributed as truncations at zero of the $N(-Z_{it}\delta, \sigma_u{}^2)$ distribution. This approach is not followed here as including Z_{it}-variables as managerial factors in the mean of inefficiency may raise endogeneity issues in the applied econometrics. Furthermore, estimating the heterogeneous factors in the mean of inefficiency within the TRE model framework requires also a truncated distribution of inefficiency which becomes highly unstable in our data. On the other hand, as noticed by GREENE (2007), allowing $\sigma^2_{u_{it}}$ to vary over individuals and/or time induces not only the heteroscedasticity but also the variation in the mean of u_{it}.[35]

6. Empirical Results

6.1 Stochastic Production Frontier Estimates

The parameter estimates of stochastic production functions for Austrian and Swiss theatres are presented in Tables 2 and 3, respectively. In each table, the results of the pooled model, the time-varying BC model and the TRE model are presented.[36] The estimates are obtained using the translog function for Austrian theatres and the Cobb-Douglas function for Swiss theatres. The results are presented for the two alternative definitions of artistic output which are the number of visitors, Y_1 and the number of tickets on offer, Y_2. All outputs and inputs variables are in natural logarithms and in the case of the translog function (Table 2) they are additionally normalized by their sample means. Hence, the coefficients of the Cobb-Douglas function and the first-order coefficients of the translog function are interpreted as the partial output elasticities evaluated at the sample mean and they show the percentage change of output in response to one percent change in input. All estimated output elasticities are positive and mostly significant at the one per cent level indicating that the increase in inputs will always increase artistic output. Consequently, the estimates provide large enough well-

35 For the half-normal model, regardless of how $\sigma_{u,it}$ varies, the mean of the u_{it} becomes then $E[u_{it}] = \sigma_{u,it}\phi(0) / \Phi(0) = 0.798$ where ϕ is the normal PDF and Φ is the normal CDF (see GREENE, 2007).

36 All models were estimated using LIMDEP version 9.0 (GREENE, 2007) except the BC model which was estimated using the FRONTIER version 4.2 (COELLI, 1996).

Table 2: Stochastic Production Frontier Estimates for Austrian Theatres

Dependent variable ($\ln Y_{it}$)	Theatre Attendance ($\ln Y_1$) Pooled	BC	TRE	Tickets on Offer ($\ln Y_2$) Pooled	BC	TRE
Constant	13.18* (0.042)	13.23* (0.075)	12.59* (0.020)	13.31* (0.042)	13.49* (0.066)	12.66* (0.021)
β_1 (ART_{it})	0.148* (0.038)	0.211* (0.057)	0.222* (0.020)	0.206* (0.038)	0.167* (0.057)	0.174* (0.017)
β_2 (ANC_{it})	0.249* (0.027)	0.045* (0.017)	0.043* (0.013)	0.200* (0.027)	0.038* (0.015)	0.038* (0.014)
β_3 (DEC_{it})	0.186* (0.031)	0.061* (0.015)	0.059* (0.012)	0.200* (0.028)	0.089* (0.015)	0.092* (0.010)
β_4 ($CAPS_{it}$)	0.352* (0.053)	0.099* (0.039)	0.109* (0.021)	0.259* (0.052)	0.117* (0.036)	0.102* (0.022)
β_{11}	–0.072* (0.020)	0.090* (0.030)	0.080* (0.018)	0.005 (0.034)	0.115* (0.028)	0.109* (0.016)
β_{22}	0.014 (0.029)	–0.033* (0.014)	–0.022 (0.013)	0.009 (0.028)	–0.022 (0.014)	–0.016 (0.015)
β_{33}	–0.008 (0.012)	0.008 (0.006)	0.007 (0.008)	0.012 (0.012)	0.012* (0.005)	0.012 (0.009)
β_{44}	–0.271* (0.047)	–0.043 (0.040)	–0.037* (0.018)	–0.298* (0.045)	–0.086* (0.036)	–0.100* (0.017)
β_{12}	–0.219* (0.046)	–0.082* (0.025)	–0.088* (0.024)	–0.229* (0.045)	–0.063* (0.024)	–0.059* (0.026)
β_{13}	0.157* (0.044)	–0.023 (0.028)	0.004 (0.025)	0.027 (0.045)	–0.047 (0.026)	–0.031* (0.015)
β_{14}	0.385* (0.078)	–0.196* (0.048)	–0.189* (0.041)	0.390* (0.081)	–0.162* (0.044)	–0.163* (0.045)
β_{23}	0.001 (0.036)	0.006 (0.019)	–0.006 (0.022)	0.025 (0.035)	0.000 (0.017)	–0.009 (0.022)
β_{24}	0.071 (0.054)	0.126* (0.031)	0.128* (0.018)	0.085 (0.054)	0.075* (0.028)	0.076* (0.023)
β_{34}	–0.006 (0.052)	0.0002 (0.026)	–0.015 (0.027)	–0.031 (0.049)	0.033 (0.023)	0.027 (0.041)
β_τ (τ – time trend)	–0.013* (0.001)	–0.003 (0.002)	–0.006* (0.0004)	–0.015* (0.002)	–0.007* (0.001)	–0.009* (0.001)
Log-Likelihood	–225.13	153.49	156.17	–188.44	210.45	208.0
λ	3.306*	6.133[a]	1.264*	0.910*	6.263[a]	0.695*
η	-	–0.004*	-	-	–0.003	-

Table 2 continued

Dependent variable ($\ln Y_{it}$)	Theatre Attendance ($\ln Y_1$) Pooled	BC	TRE	Tickets on Offer ($\ln Y_2$) Pooled	BC	TRE
Returns to scale	0.935	0.416	0.433	0.865	0.411	0.413
Technical Efficiency (TE_{it})						
Mean	0.666	0.498	0.879	0.807	0.541	0.927
Standard Deviation	0.168	0.214	0.053	0.063	0.213	0.021
Maximum	0.936	0.966	0.977	0.919	0.969	0.979
Minimum	0.379	0.177	0.553	0.529	0.183	0.750

Table 3: Stochastic Production Frontier Estimates for Swiss Theatres

Dependent variable ($\ln Y_{it}$)	Theatre Attendance ($\ln Y_1$) Pooled	BC	TRE	Tickets on Offer ($\ln Y_2$) Pooled	BC	TRE
Constant	4.926* (0.198)	7.169* (0.569)	6.209* (0.087)	4.864* (0.176)	7.117* (0.059)	6.534* (0.114)
β_1 (LAB_{it})	0.321* (0.013)	0.246* (0.035)	0.248* (0.006)	0.308* (0.014)	0.198* (0.036)	0.154* (0.008)
β_2 (DEC_{it})	0.129* (0.020)	0.014 (0.026)	0.020* (0.007)	0.102* (0.018)	0.022* (0.027)	0.018* (0.008)
β_3 ($CAPS_{it}$)	0.213* (0.033)	0.258* (0.057)	0.321* (0.015)	0.352* (0.031)	0.399* (0.055)	0.593* (0.013)
β_τ (τ -time trend)	–0.017* (0.002)	–0.023* (0.003)	–0.019* (0.001)	–0.012* (0.002)	–0.021* (0.003)	–0.014* (0.001)
Log-Likelihood	–288.74	–131.59	–107.09	–288.23	–133.41	–113.09
λ	3.164*	2.730 [a]	7.617*	3.512*	2.815 [a]	3.692*
η	–	0.008*	–	–	0.009*	–
Returns to scale	0.663	0.518	0.589	0.762	0.619	0.747
Technical Efficiency (TE_{it})						
Mean	0.640	0.606	0.728	0.634	0.574	0.741
Standard Deviation	0.174	0.231	0.172	0.177	0.225	0.149
Maximum	0.948	0.958	0.975	0.938	0.968	0.973
Minimum	0.318	0.127	0.287	0.343	0.135	0.148

For Tables 2 and 3: Standard errors in parentheses. * indicate significance at the 5 per cent level. [a] $\lambda = \sigma_u / \sigma_v$. For the BC model λ is derived from $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ and η is the scalar parameter for time-varying inefficiency.

behaved regions of the approximated underlying production technology. Furthermore, in both Tables 2 and 3, the returns to scale (RTS) are also reported which are calculated as the sum of the output elasticities. For the translog function they are additionally evaluated at the sample mean. Thus, they show a local measure of RTS, called also elasticity of scale which measures a percent increase in output due to a one percent increase in all inputs, hence due to an increase in the scale of production.[37]

In Tables 2 and 3, the output elasticities and returns to scale estimated using the pooled model differ significantly from those obtained using the BC and the TRE models. This confirms our earlier hypothesis that the first model is strongly affected by the heterogeneity bias in the production function coefficients as it ignores the theatre-specific effects in the production functions. Although the results of BC model are more or less similar to those obtained in the TRE model, we consider the latter estimator as the point of reference for the following analysis of the estimated output elasticities and returns to scale.[38]

Given the results obtained for the TRE model for Austrian theatres (Table 2), the output elasticity for artists, ART_{it}, equals 0.22 and 0.17, depending on the definition of output and it is always greater than the elasticity for ancillary staff, ANC_{it}. Furthermore, as expected, the output elasticities for artists are also greater than those for outlay on décor and costumes, DEC_{it} and those for the capital stock, $CAPS_{it}$. This confirms previous findings that artists will always remain the most important factor in the artistic production process. Similar results can be found for Swiss theatres in Table 3. The elasticity for total labour measured in man-hours, LAB_{it}, ranges between 0.25 and 0.15 for Y_1 and Y_2, respectively and it is also greater than the elasticity for DEC_{it}. This result indicates that the labour is the main factor of production in the performing arts sector. However, in the case of Swiss theatres, the output elasticity for the capital stock, $CAPS_{it}$, is always higher than the elasticities for other inputs. The important impact of the capital stock on artistic output for both Austrian and Swiss theatres may be

37 The local RTS are defined as elasticity of scale $e(x) = [dy(t) / dt] * [t / y(t)]$ where t is a positive scalar. It can be shown that at $t = 1$ and $y(t) = f(tx)$, the RTS are equal to the sum of the output elasticities so that $e(x) = [1 / f(x)]\Sigma_i^n[(\delta f(x) / \delta f(x_i)] \cdot x_i$ (see also VARIAN, 1992). The RTS are said to be increasing, constant or decreasing, when $e(x)$ is greater than unity, equal to unity, or less than unity, respectively.

38 The output elasticities of the TRE model are very similar to those estimated using the fixed effects model, not presented here. In the latter model, the returns to scale for Austrian theatres equal 0.38 and 0.39 for Y_1 and Y_2, respectively; and for Swiss theatres they range between 0.39 and 0.48. Hence, the greatest correlation bias in the production function coefficients is found for Swiss theatres, for the second output measure, Y_2.

connected with the fact that this factor indirectly reflects the usage of labour and capital inputs in a theatre. At the same time, these results suggest that *ceteris paribus* larger theatres can better expand the artistic output and that staging guest performances at other locations would be a way to increase the number of visitors.

With regard to the RTS coefficients of the TRE model estimated for Austrian theatres, they amount to 0.43, for the output measured as theatre attendance and to 0.41, for the output measured as the number of tickets on offer. Thus, at the sample mean the decreasing returns to scale are prevalent indicating that by doubling all inputs, theatre attendance and the number of tickets on offer will increase by 43 and 41 per cent, respectively. The RTS coefficients for Swiss theatres (Table 3) are slightly higher than those obtained for Austrian theatres and they equal 0.59 and 0.75 for the two output measures. Although they are also smaller than one, they indicate better possibilities of output expansion for Swiss theatres than for Austrian theatres. Furthermore, for Swiss theatres, the returns to scale vary significantly for the two alternative definitions of output and they are higher when the output is measured as the number of tickets on offer.

The evidence of decreasing returns to scale in the performing arts sector was also confirmed by Zieba and Newman (2007) for German public theatres and by Gapinski (1980; 1984) for the performing arts firms in the UK and the US. These findings imply that the performing arts face potential barriers of output expansion. These barriers may be related not only to the capacity constraints but also to the geographical or time constraints. For example, the theatres are restricted to stage only a few performances during a day. Furthermore, as repertory theatres they do not exhaust demand for the particular production as usually a different performance is staged every evening.

It is also apparent that for both Austrian and Swiss theatres, for all specifications and output measures, the coefficient of the time trend, τ, is significant and negative.[39] Its magnitude is also low, indicating that the technological change is not a significant contributor to the productivity growth of theatres in both countries. However, its negative sign confirms the general decrease in theatre attendance and in tickets on offer over time in both countries as presented in Figure 3.

39 We do not estimate the model with the time dummies as applying so many variables was not feasible for the TRE model.

The summary statistics of estimated technical efficiency (TE_{it}) scores, the log-likelihoods and the variance parameters for the compound error are also presented in Tables 2 and 3, respectively. As expected, the BC model delivers the lowest scores of technical efficiency which range, depending on the definition of artistic output, between 50 and 54 per cent for Austrian theatres and 61 and 57 per cent for Swiss theatres. The η-parameter for the BC model is significant and positive for Swiss theatres indicating that the inefficiency is increasing over time. For Austrian theatres this parameter is negative but not significant for the second output measure, Y_2. To verify importance of this parameter, the PITT and LEE's model, which is nested within the BC model, is also estimated by removing the scalar parameter from the estimations. The log-likelihood ratio tests are applied and the null hypothesis of $\eta = 0$ is accepted in favour of the PITT and LEE's specification, except for Swiss theatres when the output is measured as the number of tickets on offer.[40] In addition, the estimates of technical efficiency of the PITT and LEE's model (not presented here) are very similar to those obtained using the BC model. For the two output measures they range from 50 to 53 per cent for Austrian theatres and from 55 to 53 for Swiss theatres. This indicates that the scalar parameter of the BC model brings only a very minor change in the year to year estimates of technical inefficiency and the overall nature of the time-varying efficiency in this specification is a bit ambiguous.

The technical efficiency scores obtained using the pooled model are always located between those of the BC and the TRE models. This specification accounts for time-varying inefficiency in a more realistic way, although the unobserved heterogeneity of theatres is also absorbed in the inefficiency term. Hence, in the pooled specification, the estimates of technical efficiency are higher and much less sensitive to the specification of firm-specific heterogeneity. As we would expect, the TRE method gives on average the highest efficiency scores which, depending on the definition of artistic output, range between 88 and 93 per cent for Austrian theatres, and between 73 and 74 per cent for Swiss theatres, respectively.

Summing up, the results confirm our hypothesis that both the pooled and the time-varying BC models lead to a downward bias in the technical efficiency as they do not separate between the inefficiency and heterogeneity. On the other hand, the time-varying TRE model disentangles the time-invariant specific factors from the estimates of inefficiency. These findings also confirm the presence of unobserved

40 For Austrian theatres, the LLR test versus the PITT and LEE model is equal to 3.26 for Y_1 (d.f. = 1) and 2.26 for Y_2 (d.f. = 1), and for Swiss theatres it is equal to 3.17 (d.f. = 1) and 4.42 (d.f. = 1) for Y_1 and Y_2, respectively.

heterogeneity in the data for both Austrian and Swiss theatres and they are compatible with those found, for example, by Farsi et al. (2005) for Swiss nursing homes and by Last and Wetzel (2010) for German public theatres.

In order to strengthen these findings, the TE scores are also calculated as the averages for each theatre over the sample period. Table 4 displays the frequency distribution of average efficiency estimates in per cent of Austrian and Swiss theatres, respectively. As expected, the BC model has the widest distribution of the TE scores for the individual theatres within the sector. For example, for output measured as theatre attendance, 35 per cent of Austrian theatres and 36 per cent of Swiss theatres have technical efficiency scores which are lower than 40 per cent with the minimum efficiency score of 19 and 15 per cent for Austria and Switzerland, respectively. In contrast, for all theatres and the same output measure, the TRE model has the average TE scores above 80 per cent with the minimum score of 88 and 53 per cent for Austria and Switzerland, respectively.

In Table 5, we also examine the correlation coefficients between the technical efficiency rankings for both the individual theatres and observations. Overall, the correlations are rather weak. Much higher correlation can be found between the BC and the pooled model than between the TRE and other models. These results clearly indicate that the estimated efficiency rankings of theatres change considerably from one model to the other and that the underlying assumptions about the inefficiency and heterogeneity are crucial for the TE estimates.[41]

Summing up, the TRE model is considered as the most appropriate specification in this study as it controls for heterogeneity of theatres with regard to both the production function coefficients and the technical efficiency scores. Based on the efficiency estimates from this model, we can assume that, by the given level of inputs, theatre attendance could increase by 12 per cent on average for Austrian theatres and 27 per cent on average for Swiss theatres. The possible increases in the number of tickets on offer are 7 and 26 per cent for Austrian and Swiss theatres, respectively. Furthermore, the BC model can be used to asses the lowest possible score of technical efficiency which for both groups of theatres range in the region from 50 to 60 per cent.

With regard to the definition of artistic output, the average (also minimum and maximum) TE scores, presented in Tables 2 and 3, are very similar within the same econometric model. Nevertheless, comparing the distribution of technical

41 According to Farsi et al. (2005), the considerable differences observed in individual scores are also partly due to the large sampling errors incurred at the individual level. In fact, the efficiency estimates have robust average values as long as these values are taken over reasonably large subgroups.

Table 4: Frequency Distribution of Technical Efficiency Scores

	Efficiency Interval	Theatre Attendance ($\ln Y_1$) Pooled	BC	TRE	Tickets on Offer ($\ln Y_2$) Pooled	BC	TRE
Austrian Theatres	0.00–0.19	0	10	0	0	10	0
	0.20–0.39	0	25	0	0	20	0
	0.40–0.59	35	20	0	0	25	0
	0.60–0.79	45	35	0	40	40	0
	0.80–1.00	20	10	100	60	5	100
Swiss Theatres	0.00–0.19	0	3	0	0	3	0
	0.20–0.39	13	33	0	13	30	0
	0.40–0.59	27	17	10	33	27	3
	0.60–0.79	50	30	77	44	23	94
	0.80–1.00	10	17	13	10	17	3

Table 5: Spearman Rank Correlations between Technical Efficiency Scores

		Theatre Attendance ($\ln Y_1$) Pooled	BC	TRE	Tickets on Offer ($\ln Y_2$) Pooled	BC	TRE
Austrian Theatres	Pooled	1.0			1.0		
	BC	0.84 (0.67)	1.0		0.83 (0.64)	1.00	
	TRE	0.31 (0.38)	0.43 (0.00)	1.0	0.15 (0.31)	0.18 (–0.03)	1.0
	Tickets on offer (Y_2)	0.91 (0.85)	0.92 (0.93)	0.41 (0.67)			
Swiss Theatres	Pooled	1.0			1.0		
	BC	0.89 (0.64)	1.0		0.86 (0.62)	1.00	
	TRE	0.32 (0.65)	0.57 (0.26)	1.0	0.22 (0.58)	0.34 (0.08)	1.0
	Tickets on offer (Y_2)	0.90 (0.83)	0.92 (0.92)	0.66 (0.67)			

Correlation coefficients which are based on the number of total observations are given in parentheses.

efficiency scores between the two alternative output measures in Table 4, the scores are less dispersed and more consistent when the output is measured as theatre attendance. This implies that this output variable controls better for the heterogeneity of artistic output such as the artistic quality. The correlation coefficients between the efficiency scores which are obtained within the same econometric model but for the two alternative output measures are also presented in Table 5. The coefficients which are based on the number of total observations are quite high. However, lower correlation scores for the TRE model indicate that the individual efficiency rankings can also slightly vary, depending on the definition of artistic output.

6.2 Technical Efficiency Factors

The combined stochastic frontier models which include the estimates of technical efficiency factors are presented in Tables 6 and 7 for Austrian and Swiss theatres, respectively. Given the results presented in the previous section, the estimations are reported for the TRE model only as this method is considered as the most appropriate specification for our data. Both tables report the estimated coefficients of efficiency factors (Z_k) which were included as heteroscedastic variables in the inefficiency function. The estimates of the regional dummy variables shifting the production frontier as well as the summary statistics of the estimated technical efficiency scores are reported. The results are quite striking as the production function coefficients and coefficients of the heteroscedastic variables are highly significant for both Austrian and Swiss theatres and they are also robust with regard to different definitions of artistic output. Both the output elasticities and the technical efficiency scores are also very similar to those obtained using the basic TRE model in the previous section.

For both Austrian and Swiss theatres, the estimated coefficient of SUB_{it} is negative and significant indicating that public subsidies per seat tend to decrease variance and hence the mean of inefficiency (u_{it}) which leads to an increase in the technical efficiency scores (TE_{it}). Accordingly, the public funding is justified in the way that the received subsidies are in fact used to increase not only the number of tickets on offer but also theatre attendance by the given level of inputs. One explanation for these results might be that the public funding increases the incentives of theatre managers to behave efficiently or that the managers spend more on intangible aspects of inputs in order to improve quality which in turn increases the output of theatre. This finding is in contrast to the results obtained by Bishop and Brand (2003) for public museums although a slightly different variable was used in the latter study (see also Section 4.3).

Table 6: Estimates of Technical Efficiency Factors for Austrian Theatres

	Theatre Attendance (Y_1)	Tickets on Offer (Y_2)
Constant	12.83* (0.031)	12.35* (0.051)
β_1 (ART_{it})	0.198* (0.035)	0.272* (0.024)
β_2 (ANC_{it})	0.045* (0.016)	0.049* (0.014)
β_3 (DEC_{it})	0.057* (0.016)	0.099* (0.010)
β_4 ($CAPS_{it}$)	0.140* (0.026)	0.082* (0.082)
β_{11}	0.007 (0.024)	0.057* (0.017)
β_{22}	–0.013 (0.016)	–0.010 (0.017)
β_{33}	0.005 (0.010)	0.009 (0.008)
β_{44}	0.019 (0.027)	–0.059* (0.021)
β_{12}	–0.084* (0.025)	–0.065* (0.030)
β_{13}	0.026 (0.037)	–0.020 (0.024)
β_{14}	–0.198* (0.054)	–0.129* (0.047)
β_{23}	–0.013 (0.025)	–0.013 (0.024)
β_{24}	0.130* (0.029)	0.061* (0.029)
β_{34}	–0.016 (0.034)	0.025 (0.041)
β_t (τ – time trend)	–0.006* (0.001)	–0.010* (0.0004)
D_i (Vienna's theatres)	0.921* (0.201)	1.142* (0.067)

Table 6 continued

	Theatre Attendance (Y_1)	Tickets on Offer (Y_2)
Efficiency Determinants (Z_k)		
Constant	0.971* (0.200)	–2.722 (9.793)
γ_1 (SUB_{it})	–7.05x10^{-5}* (2.68x10^{-5})	–1.24x10^{-4}* (6.22x10^{-5})
γ_2 (NUM_i)	0.006 (0.014)	0.283 (0.750)
Log-likelihood	180.69	224.8
λ	1.81	0.79
Returns to scale	0.44	0.50
TE_{it} Scores:		
Mean	0.878	0.882
Standard Deviation	0.075	0.068
Maximum	0.987	0.974
Minimum	0.615	0.611

Table 7: Estimates of Technical Efficiency Factors for Swiss Theatres

	Theatre Attendance (Y_1)	Tickets on Offer (Y_2)
Constant	7.233* (0.097)	6.824* (0.126)
β_1 (LAB_{it})	0.169* (0.009)	0.121* (0.010)
β_2 (DEC_{it})	0.029* (0.009)	0.059* (0.011)
β_3 ($CAPS_{it}$)	0.234* (0.017)	0.400* (0.013)
β_τ (τ – time trend)	–0.015* (0.001)	–0.014* (0.001)
D_i (German-speaking theatres)	0.626* (0.026)	0.386* (0.028)

Table 7 continued

	Theatre Attendance (Y_1)	Tickets on Offer (Y_2)
Efficiency Determinants (Z_k)		
Constant	2.327* (0.166)	1.474* (0.062)
γ_1 (SUB_{it})	-2.61×10^{-5}* (1.73×10^{-6})	-6.07×10^{-5}* (7.47×10^{-6})
γ_2 (NUM_i)	–0.021* (0.005)	–0.128* (0.010)
Log-likelihood	–72.40	–100.10
λ	7.356	1.595
Returns to scale	0.432	0.580
TE_{it} Scores		
Mean	0.806	0.811
Standard Deviation	0.144	0.120
Maximum	0.991	0.959
Minimum	0.291	0.293

For Tables 6 and 7: Combined TRE model with Heteroscedasticity in the u_{it}. Standard errors in parentheses. * indicate significance at the 5 per cent level.

The coefficient of the competition factor, measured by the number of theatres in the region, NUM_i, is also negative and significant for Swiss theatres. This indicates a decrease in the variability of inefficiency and hence an increase in the technical efficiency levels (TE_{it}). In contrast, for Austrian theatres the estimate of NUM_i is positive implying a larger variance and hence a negative effect on technical efficiency. This coefficient is, however, not significant which may be due to the fact that most of theatres in Austria are located in Vienna and the effects of this variable could be partly captured by the dummy variable, D_i, included in the production frontier. The latter variable is in fact positive and significant indicating that theatres in Vienna produce greater artistic output by the given level of inputs, a result that one could expect. Additionally, for Swiss theatres the dummy variable for German-speaking region is also positive and significant, indicating that by the given inputs levels, the theatres in this part of Switzerland produce on average more than the theatres located in French-speaking part of Switzerland.

In order to confirm the real impact of the managerial factors, SUB_{it} and NUM_i, on the estimated TE scores, the sample was also split into values below, and values equal or above the median for both efficiency indicators. Table 8 presents the average technical efficiency scores calculated for these sub samples over the time period examined. The average TE scores are presented for both the basic TRE model, estimated in the previous section and the combined TRE model which includes both the heteroscedastic variables and the regional dummy variables. The t-tests of the statistical significance of the difference in the technical efficiency means are also reported.[42] Es expected, for both Austrian and Swiss theatres and for the two TRE model specifications, the mean efficiencies for low SUB_{it} are significantly lower. The mean TE scores for low NUM_i are also significantly lower for Swiss theatres but not for Austrian theatres. For the latter theatres, the mean efficiencies are higher for low NUM_i, although they are not significant. Thus, we find strong evidence in our data to support our regression results and hence our hypotheses about efficiency indicators.

Furthermore, to discriminate between the basic TRE model and the combined TRE model with heteroscedasticity, the log-likelihood ratio tests are applied. The null hypothesis that the variance of inefficiency is not a function of the managerial factors and that the dummy variables have no effect on the production frontier, is always rejected.[43] This implies that the model including the Z_k-variables as explanatory factors provides a better fit to the sample data. Hence, the presented combined TRE model is a useful extension of our analysis as it explains the possible sources of inefficiency and also incorporates both the observed and unobserved heterogeneity of theatres.

42 The Kruskal-Wallis rank tests were also obtained for the sub samples of theatres. Since the results of these tests did not differ from those presented in Table 8, they are not presented in order to avoid the repetition of results.

43 The test is based on the likelihood values obtained for the TRE model in Tables 2 and 3 and the combined TRE model in Tables 6 and 7, respectively. For both output measures, the LLR test versus the combined TRE model (nested model) equals 49 (d.f. = 3) and 34 (d.f. = 3) for Austrian theatres, and it equals 69 (d.f. = 3) and 26 (d.f. = 3) for Swiss theatres.

Table 8: Mean Comparison Tests of Technical Efficiency Scores

	Theatre Attendance (Y_1)		Tickets on Offer (Y_2)	
Estimated Mean TE_{ikt}	TRE	Combined TRE	TRE	Combined TRE
Austrian Theatres				
SUB_{it} low	0.874	0.847	0.926	0.871
SUB_{it} high	0.882	0.903	0.928	0.891
t-ratio	–17.5*	–12.6*	–3.22*	–4.03*
NUM_i low	0.879	0.913	0.927	0.943
NUM_i high	0.878	0.857	0.927	0.845
t-ratio	1.36	12.2*	1.22	32.6*
Swiss Theatres				
SUB_{it} low	0.691	0.765	0.730	0.769
SUB_{it} high	0.765	0.847	0.752	0.853
t-ratio	–11.2*	–7.77*	–1.96*	8.52*
NUM_i low	0.719	0.794	0.731	0.808
NUM_i high	0.740	0.822	0.755	0.815
t-ratio	–2.88*	–2.55*	–5.05*	–0.78

Low and high groups of theatres (with 536 observations for Austrian theatres and 526 observations for Swiss theatres) are split at the median of the efficiency determinant. * indicate statistically significant difference at the 5 per cent level.

7. Conclusion

This study demonstrates that the estimated production technology and technical efficiency scores of theatres depend both on the econometric specification (different assumptions about the inefficiency and heterogeneity) and the measurement of artistic output. Nevertheless, despite many difficulties in obtaining the robust estimates, the results are reassuring. We firstly confirm previous findings that the estimated output elasticities with regard to all inputs are positive, with the artists being a more important factor of production than ancillaries or capital. The number of seats in a theatre is another significant factor of production. There is also evidence of decreasing returns to scale for both Austrian and Swiss theatres which complies with our hypothesis that there is little room for output expansion.

The main findings of this study relate to the analysis of technical efficiency scores of theatres. The results are consistent with pervious studies and suggest that the alternative panel data models, such as the true random effects model of Greene (2005), can be used to exploit different assumptions about the inefficiency and heterogeneity of theatres. Assuming technical efficiency as a time-varying and dynamic phenomenon, this model treats all time-invariant effects as the unobserved heterogeneity which seems to be a reasonable assumption. This model is especially useful when the data limitations prevent us from using good measures of artistic output and only simple quantifiable performance targets such as the number of visitors or tickets on offer are available. In particular, if some quality aspects of artistic output are time-invariant such as, for example, the reputation of a theatre, they can be separated from the inefficiency term by using this specification.

The findings further indicate that, given the results obtained using the true random effects model, Austrian theatres are on average more technically efficient than theatres in Switzerland. Such findings may be, however, a result of applying slightly different variables, time periods and quite restrictive data sets for both groups of theatres. As discussed earlier, this mainly applies to the definition of labour input which for Swiss theatres is based on the assumption of homogenous salaries. Therefore, the results can be seen only as first attempts to evaluate efficiency of these organisations. Nevertheless, this analysis confirms that the theatres in both countries are very heterogeneous with regard to the production of artistic output.

Another purpose of this study was the examination of managerial factors that affect the technical efficiency scores of theatres. These factors were included as heteroscedastic variables in the inefficiency function of the true random effects model. The estimated coefficients are very consistent and clearly confirm the positive effect of public funding on technical efficiency of theatres which may in turn be connected with producing intangible aspects of artistic output such as quality. As expected, the competition level, measured here as the number of theatres in the region, may also increase the incentives of theatres to be more efficient. The regional differences which affect directly the production technology are also important. The statistical tests additionally confirm that including all these factors as observed heterogeneity of theatres is a useful extension of the analysis of efficiency.

On the whole, the panel data models presented could prove as important public policy instruments in order to examine the technical efficiency and efficiency factors of theatres provided that detailed data on output and inputs are available. As proposed by Farsi et al. (2006) with regard to cost efficiency analysis, public authorities could predict an interval of the expected artistic output, measured as the number of visitors or tickets on offer by the given level of inputs and also by accounting for both unobserved and observed characteristics of theatres. The theatres would be then required to justify any shortage in the predicted output levels by the given level of public funding. Thus, the efficiency of the performing arts organizations could be compared not only with regard to their costs but also with regard to their non-financial artistic goals.

Appendix: Variables and Data Sources

Variable	Description
Theatre Attendance, Y_{1it}	Total number of visitors during the yearly production season (without guest attendance). It consists of visitors attending drama performances (also children's and youth performances), musical theatre (opera, operetta, musicals), ballet and classical concerts.
Tickets on offer, Y_{2it}	The number of performances multiplied by the number of seats in a theatre. Some theatres have more than just one theatrical venue. In such case, the number of tickets on sale is calculated for each venue separately (i.e. the number of seats available for the particular stage was multiplied by the number of performances produced during the season on that stage). The number of seats on offer for each venue was then summed up to get the total number of tickets on offer.
Artists, ART_{it} *(Austrian Theatres only)*	The number of artistic staff and technical staff. This includes artistic directors, stage managers and technicians, solo artists for opera/operetta, solo artists for drama, guest artists, ballet members, choir and orchestra members.
Ancillaries, ANC_{it} *(Austrian Theatres only)*	The number of administration and house staff.
Man hours, LAB_{it} *(aggregated labour input)*	Total man-hours are calculated by dividing yearly total personnel expenses in theatre by the yearly wage rate for all sectors for Switzerland, and by the industry wage rate for Austria. The wage rates are derived by dividing the total compensation of all employees by the total working hours of the employees. The nominal wage rates were deflated using the nominal wage rate index for each country with the base year 2000 and they were converted into yearly theatre seasons equivalents.
Décor & Costumes, DEC_{it}	Expenses for décor and costumes are deflated to 2000 prices by using the Whole Sale Price Index (WPI) for Austria (in EUR) and the Implicit Price Deflator (GDP) for Switzerland (in CHF); the expenses are also adjusted for the yearly theatre seasons for Austrian theatres.
Capital stock, $CAPS_{it}$	Capital stock is measured by the number of all seats available in all venues of theatre *i* and season *t*.

Variable	Description
Subsidy per seat, SUB_{it}	The total level of public subsidies deflated into 2000 year prices in EUR (Austria) and in CHF (Switzerland) by using the WPI deflator (Austria) and GDP deflator (Switzerland), and divided by the number of seats in theatre *i* and season *t*.
Number of theatres, NUM_i	The number of non-profit theatres which are located in the same federal region (Austria) or in the same canton (Switzerland) where theatre *i* is located.
Regional dummy variable, D_i	For Austrian theatres, it set to 1 if a theatre is located in Vienna and zero otherwise. For Swiss theatres, it is set to 1 if a theatre is located in the German-speaking part of Switzerland and 0 otherwise.

Country	Data Sources
Austrian Theatres	1) *Theaterstatistik*, Deutscher Bühnenverein, 1969/70–2004/05, Tables from 1 to 5 of Appendix 1 2) '*Statistik Austria*', Federal Statistics Office, ISIS Data Base (Integriertes Statistisches Informationssystem), www.statistik.at 3) EcoWin Pro Database
Swiss Theatres	1) *Theaterstatistik*, Deutscher Bühnenverein, 1969/70–2004/05, Tables from 1 to 5 of Appendix 2 2) '*Statistik Schweiz*', National Accounts of Federal Statistics office, www.bfs.admin.ch/bfs/portal/de/index/themen.html 3) EcoWin Pro Database

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SUMMARY

This article explores the measurement of the production technology and efficiency of the performing arts sector. The stochastic frontier analysis has been used to estimate the technical efficiency scores for 20 Austrian and 30 Swiss non-profit theatres over 36 and 26 years, respectively. The number of visitors and tickets on offer are considered as two alternative measures of artistic output. The results indicate that individual efficiency estimates are very sensitive to the econometric specification of the unobserved heterogeneity of theatres. In particular, econometric techniques which do not account for this heterogeneity produce much lower efficiency levels. The indefinable dimension of artistic output such as theatre-specific quality may also have an important influence on efficiency estimates. The empirical analysis also delivers the first insights into the impact of exogenous factors on technical efficiency such as the number of theatres in the local area, regional differences and the level of public subsidies.